Radio Frequency Identification (RFID)

Market Study

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Introduction

What is AIT?

Automatic Identification Technology (AIT) is a generic name given to devices used to automate data collection in a variety of applications, with the goal of providing cost savings by expediting the collection of accurate data. The AIT industries have been growing rapidly in the past five years, as both the DoD and commercial markets continue to identify uses for these devices. The primary AITs that DoD has been using are Linear Bar Codes, Two-Dimensional Bar Codes, Radio Frequency (RF) Identification (RF/ID), Integrated Circuit Cards (ICCs), Memory Cards, and Laser Cards.

AIT Program Management in the Air Force

The AF AIT Program Management Office (PMO) is located at Wright-Patterson AFB in Ohio. It was established in 1994 by combining the AF Logistics Applications of Automated Marking and Reading Symbologies (LOGMARS) and the AF Microcircuit Technology in Logistics Applications (MITLA) PMOs. As part of DoD's continuing effort to streamline management, most of the services have combined their LOGMARS and MITLA PMOs into a single AIT PMO. The Air Force has followed suit. On a DoD level, these programs are managed by a Senior Advisory Group (SAG) consisting of Assistant Secretaries of the Air Force, Army, Navy, Marine Corps, DLA and GSA.

The AF AIT PMO manages all Air Force projects, and is responsible for managing every aspect of the AIT program in the Air Force. This includes continued development of DoD standards within the AIT arena, participating in various DoD AIT working groups, educating potential users regarding the capabilities of the technologies, cradle to grave project management, and the overall coordination, direction, development, and implementation of AIT within the Air Force. The AF AIT PMO personnel are all active project managers and are available to answer any questions you may have about the AIT program, as well as provide assistance to you in submitting your concept paper. The AF AIT PMO can be contacted as follows:

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Why this Study?

As the focal point for AIT in the Air Force, the AF AIT PMO maintains up-to-date market data on a variety of AIT. This is done by attending conferences & standards groups, meeting with vendors, attending equipment demonstrations, and collecting product literature. This study is yet another way in which the AF AIT PMO stays in touch with state-of-the-art AIT, and provides this information to DoD customers.

Radio Frequency Identification (RFID) Technology Overview

Radio Frequency technology is a relatively new approach to automatically identifying, categorizing, and locating people and assets over relatively short distances (a few inches to hundreds of feet).

Background

Automatic identification technology began with bar code technology and the computer. Any item with a bar code label can be identified by simply scanning the bar code with a handheld or fixed scanner, and then using a computer to translate the scanned code into meaningful information. The computer does this by comparing that code with other codes in a large table (i.e. a "look-up" table) stored in a central data base. Other relevant data such as the date, time and location can also be automatically recorded when the bar code is scanned. This technology has relieved the user of the tedious and error-prone task of reading an alphanumeric label, and manually entering the contents into a database or onto a form.

With bar code technology, the time required to identify objects and enter data into a data base has been significantly reduced for many logistics-related operations at warehouses, retail stores, battlefields, hospitals, etc. In addition to saving time, this technology has significantly improved the accuracy of both asset identification and data entry. Bar codes do have some limitations, and may not be read if they are torn, dirty, iced up or printed out of specification. They are also limited in the amount of information that can be stored, though this has been increased with the new two-dimensional bar codes, and portable data files. Finally, bar code technology requires that the labeled objects be located and brought to the reader to be identified. The technology does not allow for "self-location".

Technology and Method of Operation

Radio Frequency Identification (RFID) is a new technology which can be used in applications that go beyond the limits of bar codes. RFID labels are known as tags or transponders, and contain varying amounts of information ranging from a permanently stored ID number programmed into the tag at the factory, to128K bytes of read/write memory. The reader/writer unit is usually referred to as an interrogator, and may be a stand-alone handheld device or a fixed device controlled by a computer.

RFID interrogators communicate with tags through the use of radio frequency (RF) energy. The interrogator sends out an RF signal which "wakes up" the tag, and the tag transmitts information back to the interrogator via RF. In addition to reading the tag, the interrogator uses RF energy to write new information to the tag. This enables the user to alter the information stored in the tag from a distance. Interrogators can be networked together so as to provide nearly unlimited coverage for a system.

Applications

The potential applications for this technology are numerous. RFID technology offers inexpensive read-only tags, which are generally short range (a few inches to a few feet), or more expensive long range, read/write devices with large memory capacities. The short range tags can be used in lieu of bar codes for identifying objects in harsh environments. For example, these tags are used in factories to track items through their production cycle. Given the short read range of these tags, the item typically travels on a conveyor bringing it in close proximity to the interrogator. Short range systems are also used for personal identification and access control operations. The identity of the individual can be determined either with a very short range RFID card read when held within a few inches of the reader, or with somewhat more expensive systems which can read the card even when it is kept in a pocket.

The longer range tags are finding many applications in transportation, as these tags can be read at distances up to several hundred feet. They are being used to identify vehicles on roadways, as well as for automatic toll collection. Once the vehicle's account number is read by the interrogator, a debit is made to the vehicle owner's account, which may be located in a secure central data base or in the tag itself. Additionally, rail cars are being tagged so that the railroads will have real-time location data of their rail cars. Trucking companies and intermodal container carriers are using these systems to identify their vehicles (and in some instances their contents) electronically as the tagged containers move past interrogators in ports or truck terminals.

These longer range tag systems are also capable of being used in depots, factories, and warehouses to provide automated inventory of assets with no human involvement. In addition to automatically identifying the assets, these systems can locate the assets and direct a person to the asset very quickly. There are many other potential uses for this technology both in military and commercial applications, especially as the cost of the systems continue to decrease.

Cost

The small short range tags can be smaller than a fingernail and cost $1- $20. The longer range *read-only* backscatter devices generally cost $10-$30, while the *read/write* backscatter versions cost $30-$75. Active read/write tags (battery required) cost $55-$200 depending on features and size of memory. All of these costs are moving down, however the cost reductions for active tags may not be as dramatic as with backscatter tags due to the requirement for a battery in an active tag.

The cost for an interrogator unit varies from $500 for a very short range tag interrogator to $2000 for an active tag interrogator, and up to $8000 for a backscatter interrogator. Vendors also offer fixed and handheld interrogators and some specialized software for their equipment.

Standards and Regulations

The Federal Communications Commission regulates the use of all RF transmitting devices in the US. Similar agencies perform that function in other countries. In the US and other countries transmitting devices can either require licenses to operate in specific locations at given frequencies

and power levels, or they may be granted a blanket certification to operate anywhere if they operate in an allowable frequency band and remain below certain transmitted power levels. The allowable frequency bands for the latter type of operation are proscribed by the FCC. Backscatter interrogators typically require licenses while the short range and the active interrogators can be certified to operate without licenses.

As of the preparation time of this document, there is one ANSI/ISO standard for RFID tags. It is for use with intermodal containers. Other standards include a mandatory standard from the American Association of Railroads and a voluntary standard from the American Trucking Association. There are two other national standards in some stage of development, i.e. a standard for Automatic Vehicle Identification (AVI) being developed by ASTM and a generic active RFID tag standard being developed by the X3T6 Committee of ANSI. Finally, the State of California has published a standard which is to be used for AVI applications within the state. The State of Kansas has required the California standard be used in its automatic toll collection on the Kansas Turnpike.

A summary of the responses to the Air Force AIT PMO's RFID market survey follows, along with brief profiles on the responding companies and a glossary of terms used in the summary table.

Survey Respondents

The RFID market survey was sent out to 24 companies. Responses were received from 10 companies.

Company Name	Responded?
Amtech Corporation	no
Allen-Bradley	no
ASGI	yes
AT/COMM	yes
Balogh T.A.G.	no
British Technology Group	no
Checkpoint Systems	no
Cotag International, Inc.	no
Dysys, Inc	no
Enterprise Network Applications	no
Hughes Aircraft	no
Hughes Identification Devices	no
I.D. Systems	yes
Indala	no
Intellitag	yes
Lanex Corporation	no
Mark IV	no
Micron Communications, Inc.	no
Rand Technologies	yes
Saab Scania Combitech AB	yes
Savi Technology	yes
Single Chip Systems	yes
Texas Instruments	yes
X-Cyte, Inc.	yes

The 10 respondents are grouped into categories based on whether they currently (or are planning in the near-term) to manufacture active, read/write tags, or manufacture passive backscatter or inductive tags.

Active Read/Write Tags

Company	Comments
ASGI	Developing an active read/write tag
AT/COMM	Currently manufactures an active read/write tag
I.D. Systems	Developing active read/write tags
Intellitag	Developed a prototype active read/write tag
Rand Technologies	Developed a prototype active read/write tag
Savi Technology	Currently manufacture an active read/write tag

Inductive or Backscatter Tags

Company	Comments
ASGI	Manufactures a backscatter device based upon Eureka technology
Intellitag	Manufactures backscatter read/write tags with up to 150 foot range
Saab Scania Combitech	Manufactures backscatter read/write tags with up to 150 foot range
Single Chip Systems	Developing short range read/write <$1 tags; prototypes expected 1st quarter 95
Texas Instruments	Manufactures short range inductive tags with read-only and read/write capability
XCI, Inc.	Manufactures read-only, short range backscatter tags

Company Profiles

ASGI

ASGI is a small privately held company located in Reston, Virginia. The company is manufacturing a passive, short range, low frequency, read/write tag, which sells in the price range of $18.50-$25 based upon quantities purchased. The company is developing an active longer range, higher memory tag whose characteristics have not yet been publicly released. The company is primarily involved in the asset tracking and commercial/industrial vehicle identification markets.

AT/Comm

AT/Comm is a small, privately held company, which is headquartered in Marblehead, Massachusetts. The company manufactures high frequency read/write tags with very long range capability (up to 1/2 mile). The company's tag price is $38 (quantities unknown). The company has not released its marketing areas, but it is public knowledge that it is actively involved in the electronic toll collection market.

ID Systems

ID Systems is a small, private company which is currently developing an active tag with a read/write capability and a memory capacity of up to 64 Kbytes. The company is privately held and is headquartered in New York City.

Intellitag

Intellitag is a private joint venture corporation comprised of two publicly held companies, Motorola and Amtech. The company has offices in Dallas and Scottsdale, Arizona. The tags are high frequency passive devices with a memory capability of up to 2 Megabytes, and an effective data rate of 37.5 Kbytes/second. The product prices vary from $35-$75 based upon options and quantities purchased. A compatible active tag has also been developed, and will be marketed this year. The products are used in the electronic toll collection and transportation logistics industries. An active version of the Intellitag is due to be available in the spring of 1995.

Rand Technologies

Rand Technologies is a small, privately held company, which has demonstrated an active, long-range, read/write tag with built-in sensors for monitoring the physical status of assets. The company is headquartered in Fairfax, VA. The memory capacity of the tags will be up to 128 Kbytes with 64 Kbytes being user-programmable. The tags are expected to be priced in the $100-$300 range based upon quantities purchased. The primary markets which these tags are directed toward include: asset security, nuclear materials tracking and monitoring, and warehouse inventory management.

Saab Scania Combitech Traffic Systems AB

Combitech is a division of the large Swedish automaker, Saab Scania. The company is headquartered in Sweden. It manufactures high frequency, passive read/write tags with memory capacity of up to 8 Kbytes. The company's tag systems have very high data transfer rate (similar to Intellitag). The tag prices range from $32-$40 US. The primary market areas served by

Combitech's products are: electronic toll collection, automatic vehicle identification, and commercial transportation.

Savi Technology

Savi Technology is a small business headquartered in Mountain View, California. They develop and manufacture active RFID systems. Savi's products have long range and a read/write capability, as well as having memory capacity up to 128K bytes. The prices of their tags range from $50-$190 based upon options and quantities purchased. Savi manufactures both fixed and handheld interrogators. Their primary market has been military logistics. The company plans to explore other commercial transportation, materials tracking and monitoring, and warehouse inventory management applications.

Single Chip Systems

Single Chip Systems is a small, privately held company based in San Diego, California. The company is developing very inexpensive, short range, passive read/write tags No tags are yet in production. The company's target price for the tags is $0.25-$1.00. No information has been made available on the market applications for the products.

Texas Instruments (TI)

TI is a very large, public company, headquartered in Texas. The company's RFID business (TIRIS) has two primary product areas. These are passive low frequency and high frequency tags, which can be read-only or read/write. The low frequency tags are used in the animal tracking, electronic key, and access control markets, while the high frequency devices are marketed to the electronic toll collection industry. The low frequency tags have prices ranging from $3-$23.

XCI

XCI (formerly X-Cyte) is a small, privately held company in San Jose, California. The company manufactures read-only, passive tags, based upon surface acoustic wave materials. The company's tag products have a price range of $10-$50. The company has been active in the vehicle tracking market, inclusive of electronic toll collection and parking applications.

Radio Frequency Identification Survey Results

Company (Type of Product)	Line of sight required?	Read/Write?	Memory Size	Range	Multiple Tag Read Capability?	Frequency	FCC Site License Required?	Time to Download 128 Kbytes	Handheld Interrogator Available?
ASGI (Passive, active tag under development)	Yes	Yes	115 bytes	<2.5 meters	Yes	66/132 KHz	No	Not applicable	No
AT/Comm (Active)	No	Yes	10 Kbytes	>2000 feet	Yes	2.45 and 5.8 GHz	Yes	<30 minutes	Yes
ID Systems (Active tag under development))	No	Yes	64 Kbytes	50 meters	Yes	UHF, 915 MHz, and 2.54 GHz	No	2 minutes	Yes
Intellitag (Passive, and active)	No*	Yes	2 Mbytes	>10 meters **	Yes	915 MHz and 2.54 GHz	yes ***	<4 seconds	In development for active tag
Rand Technologies (Active)	No	Yes	128 Kbytes	150 meters	Yes	903-928 MHz	No	< 2 minutes	In development
Saab Scania Combitech (Passive)	No*	Yes	8 Kbytes	> 10 meters	Yes	2.45 and 5.8 GHz	No	<5 seconds	Yes
Savi Technology (Active)	No	Yes	128 Kbytes	150 meters	Yes	315 or 433 MHz	No	< 28 minutes ****	Yes
Single Chip Solutions (Passive)	Yes	Yes	1 Kbyte	<2 meters	Yes	125 KHz	No	Not applicable	Yes
Texas Instruments (Passive)	No	Yes	512 bits	<2 meters	No	120 KHz	No	Not applicable	Made by other companies
XCI (Passive)	Yes	No	26 bits	10 meters	Not in the current products	915 MHz	No	Not applicable	In development

* Range is reduced if line-of-sight situation does not exist.
** The active version with the same protocol has a range of about 150 meters.
*** The active version will not require a site license.

**** Capability exists to intelligently search for data. Direct connect downloads < 1 minute.

Definitions of RFID Terms

Passive and Active. RF tags communicate with the interrogation units via radio frequency radiation. The electrical power to drive the tag's communication capability can either be derived from the incident radiation arriving from the interrogation unit or by an electrical supply source (e.g., a battery) located on the tag. Tags which derive their transmitting power from the radiation impinging on the tag are known as passive devices. They either use the magnetic field from the interrogator's signal or the electric field. If they use the former, then they are known as inductive tags, which use low frequency RF radiation and have very short communication distances. When the electric field is used to power up the tag, these devices are referred to as backscatter or reflective tags and usually utilize higher frequencies and achieve longer communication distances. When the tag has its own power source for transmission, those tags are referred to as active tags and can usually achieve even longer distance communication.

Range. The effective maximum distance over which the tag and interrogator can successfully communicate.

Line-of-Sight In order for any communication to occur, a signal transmitted from interrogator or the tag must reach the other device. Unless the device is in a completely shielded metal enclosure, some radiation will usually reach the device. This radiation may arrive in a direct line of sight path or it may arrive via scattered reflections from man-made or natural terrain features. However, the amount of radiation (and its phase) which reaches the device is very important. If a passive device is being used, sufficient radiation must reach a tag so that the tag can not only can interpret the information content of the signal, but must also be sufficient to power the signal transmission of the tag back to the interrogator. Therefore, passive devices usually have a significant degradation in their range when they are not in the direct line of sight to the interrogator, because otherwise they will not receive enough RF radiation to allow for a successful re-transmission of RF radiation. Active tags are much more non-line-of-sight tolerant, because they only need to receive enough radiation to allow for the incoming signal to be successfully interpreted. They then re-transmit using their own on-board power supply.

Read/Write Capability. Some RF tag systems only allow for data to be encoded once in the tag's memory. This encoding may be performed in the factory or by the use of special equipment in the field. Those tags are referred to as read-only devices. Tags, whose memory may have data written to them remotely and repeatedly via RF signals are referred to as read/write devices

Multiple Tag Read Capability. In some instances it is necessary to identify all tags in a given area. This can always be accomplished if one tag at a time is placed in the RF field of the interrogator. However, if the tags are randomly spread out over an area, it is desirable for the interrogator to transmit a command over the entire area (this is known as an omni-directional signal transmission) requesting the identity of all tags. If all tags were to simultaneously respond to that command then the various RF signals would interfere with each other and the interrogator would receive only RF noise. Many systems have been developed which allow the tags to be individually "heard" by the interrogator thus avoiding the RF chaos of many interfering signals. This multiple tag reading capability is usually achieved by randomizing the response of each tag

into different time slots or having each tag respond at a slightly different non-interfering frequency.

Data Rate. The speed at which data can be read from or written to the tag via a radio link. This is usually expressed in bits or bytes per second or baud, which is bits per second. Because most systems will have time delays due to error checking and moving data around the internal memory of the tag, the full data rate is not actually achieved in practice. Furthermore, in some cases, there will be further limits on the data rate imposed by the requirements of the Federal Communications Commission (FCC) or other similar regulatory bodies in countries outside the US. Therefore, the relevant value used in the survey table is the amount of time which is required to move 128K bytes of data into or out of the tag memory. In some cases, companies do not show the capability for 128K bytes of memory in their current product line, so they were asked to compute the time for a 128K byte transfer if their product had that much memory.

FCC Licensing. In the US all devices which emit RF radiation are regulated by the FCC to avoid radio chaos from interfering signals. The FCC can either provide a vendor of transmitting systems with a license to transmit at a given site using a given frequency and a maximum transmission power level, or it can provide a certification that at a given frequency the power levels are so low as to not pose a major interference threat. When a company's products are regulated in the latter manner they are said to require no license and are certified under the FCC's Part 15 Rule for unlicensed certification. This is important, because one might want to use tags and interrogators in a variety of locations and not need to go through the license application process for each individual location where the system is to be used.